DEPARTMENT OF NATURAL RESOURCES
SASKATCHEWAN

BULLETIN No. 1 (Revised Edition)

Instructions for the Development of DUGOUTS DOMESTIC DAMS and IRRIGATION PROJECTS

C. J. McGAVIN, *Chief Engineer*,
Water Rights Branch.

HONOURABLE W. F. KERR, *Minister*.

J. R. HILL, *Deputy Minister*.

REGINA:
THOS. H. McCONICA, King's Printer
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LETTERS OF TRANSMITTAL

WATER RIGHTS BRANCH
DEPARTMENT OF NATURAL RESOURCES

REGINA, *March 12, 1937.*

HONOURABLE W. F. KERR,
Minister of Natural Resources.

I have the honour to transmit herewith a report dealing with provincial regulations, and methods of construction for domestic water supplies and small irrigation projects.

It is believed the report will stimulate development and give general information regarding the opportunities for improving conditions throughout the drought area.

I wish to take this opportunity of expressing thanks to the members of the staff for assistance given in the work of producing the report, and would recommend that it be published as a bulletin of this office for distribution.

C. J. MCGAVIN, R.P.E., M.E.I.C.

REGINA, *October 15, 1938.*

HONOURABLE W. F. KERR,
Minister of Natural Resources.

I am pleased to inform you that the bulletin "Instructions for the Development of Dugouts, Domestic Dams and Irrigation Projects" has been favourably received to the extent that the issue is now entirely depleted.

I have the honour to submit for your approval a revised issue, with additions, that is hoped will meet the increased public demand, and I would recommend that this issue be published as Bulletin No. 1 (revised).

C. J. MCGAVIN,
Chief Engineer.

The Development of Small Water Supplies and Irrigation Projects in Saskatchewan

The Water Rights Act.

All surface waters in Saskatchewan are vested in the Crown in the right of the Province of Saskatchewan, and are administered under the provisions of *The Water Rights Act.*

Under this Act the Minister is enabled to give protection to property rights and to prevent injury to any one who may be affected by, or interested in, the diversion or impounding of Saskatchewan waters.

The right to use water by any individual or company must be obtained under the provisions of the said Act. Any person contemplating the construction of any project, no matter how small, for the diversion or impounding of water should first apply to the Water Rights Branch, Department of Natural Resources, 501 Leader-Post Building, Regina, for a water right. A memorial form will be supplied which shall be properly filled out in ink and filed with the Branch, together with a plan of the proposed project. In certain areas, from time to time defined as the drought areas, plans will be prepared by Engineers of the Water Rights Branch. If everything is in order, a certain quantity of water will be reserved for the use of the applicant, and authorization will be issued by the Department of Natural Resources to the applicant allowing him to proceed with the construction. When and if construction has been completed according to the authorization, the Minister will issue a license to the applicant setting out the quantity and rate of diversion to which the applicant is entitled.

The Irrigation Districts Act.

This is an enactment regulating the formation and operation of "Irrigation Districts." It is applicable to the larger irrigation schemes where a number of individuals organize to form a district for the purpose of constructing and operating an irrigation project.

The Water Users Act.

This is an enactment regulating the formation of "Water Users' Associations". It is applicable to situations where three or more individuals wish to co-operate in the construction, operation and maintenance of works for the use of water for irrigation or other purposes.

The Prairie Farm Rehabilitation Act.

In order to assist in the development of water resources in the three prairie provinces the Dominion Government passed an Act known

as the *Prairie Farm Rehabilitation Act.* This Act provides, among other things, the Federal expenditure of certain sums each year in giving financial assistance and engineering service to the farmers to aid them in developing surface water resources on their farms by the excavation of dugouts and the construction of stock watering dams and irrigation schemes.

A committee was formed called the "Water Development Committee" with headquarters at 910 McCallum-Hill Building, Regina, Saskatchewan.

All applications for financial assistance must be made to that office, after which an inspection of the proposed project will be made by a Government engineer or inspector. Engineering investigation is at present the direct responsibility of the Provincial Water Rights Branch, Department of Natural Resources, 501 Leader-Post Building, Regina, Saskatchewan, as far as all stock watering and irrigation schemes are concerned when the applicant farmers share in the cost of the work of construction, and this responsibility also entrusts the approval of community projects for similar purposes.

DUGOUT CONSTRUCTION

A dugout consists of a deep pit excavated in a drainage basin for the purpose of storing water for farm or community purposes and will, if the conditions are suitable, store enough water to give an all year domestic supply to the farmer or the community served.

Before making application for a survey, or for financial assistance, possibilities should be investigated with reference to:

(a) A suitable site.
(b) Drainage area tributary to the site.
(c) Type of subsoil at the site.

Choosing the Site.

Other things being equal, a site should be chosen which will be convenient and easily accessible. However, the extent of the drainage area, that is, the number of acres from which water will run into the dugout, and its nature are the most important points to be considered.

Size and Nature of Drainage Area.

Experience has shown that for the average size dugout, not less than *35 acres* of drainage area should be tributary to it.

Capacity and Size of Dugouts.

		Excavation Cubic Yards	Full Capacity Imp. Gals.
100′ x 60′ x 10′	Sides 2:1 Slope Ends 4:1 Slope	988	166,250
120′ x 60′ x 10′	"	1,284	216,000
150′ x 75′ x 10′	"	2,340	394,000

		Excavation Cubic Yards	Full Capacity Imp. Gals.
100′ x 60′ x 12′	Sides 1½:1 Slope Ends 4 :1 Slope	1,099	185,000
120′ x 60′ x 12′	"	1,472	248,000
150′ x 70′ x 12′	"	2,485	418,000

The effective capacity will be about two-thirds the full capacity due to seepage and evaporation losses.

Dugouts 120′ x 60′ x 10′ will give a daily supply of approximately 400 gallons.

Naturally the dugout should be placed at the lowest point in the drainage area, and since this is the case, care must be taken to ensure that no barns or manure piles are found on the drainage area, as the water is almost certain to be polluted.

Subsoil at the Site of the Dugout.

When a site has been chosen, test holes should be put down with a post-hole auger, to determine the type of subsoil. Clay, or a good clay-mixture, is necessary, as a dry sand or gravel subsoil may not hold water.

Making Application.

When the farmer has satisfied himself that the above conditions are complied with he should make application to The Prairie Farm Rehabilitation Office, 910 McCallum-Hill Building, Regina, Saskatchewan, asking for application form for financial assistance and a memorial form for water right, the latter form being filed with the Water Rights Branch. When these are received they should be filled in and signed in ink as instructed, and mailed to the proper address.

After the application has been submitted the applicant shall wait until the proposed site has been inspected by a Government engineer. If the site is found satisfactory to the engineer, the applicant may then be given authority to proceed with construction, subject to the acquisition of such rights-of-way as may be required.

Construction.

Dugouts may vary in size, depending upon the water available, the uses to which they will be put and the amount of work which the applicant is prepared to do. Normally, a dugout should have top dimensions of 60 feet by 100 feet and 10 feet deep, with side slopes of 2 to 1 and end slopes of 4 to 1. (See Fig. 1.) This will give a bottom 20 feet by 20 feet in size. A dugout 12 feet deep with 1½ to 1 side slopes would be better. The minimum size of dugout should be 50 feet by 100 feet by 10 feet deep, with slopes as above. The 4 to 1 slopes at the ends will enable horses to climb out of the dugout more easily during construction.

TAKEN FROM MANITOBA AGRICULTURAL BULLETIN, 1922, BY. G.L. SHANKS. PROF. OF AGRIC. ENGINEERING.

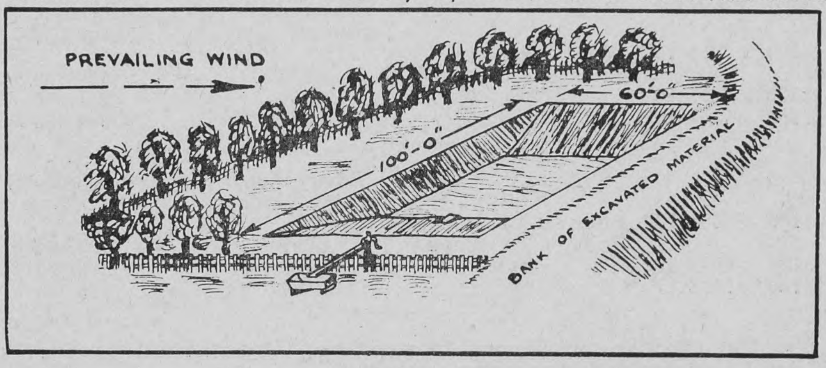


FIGURE. 1.

Construction, if done with horses, is best accomplished by the use of the Fresno scraper. These can usually be obtained from municipalities. If done by machinery, a caterpillar tractor equipped with a bull-dozer would be an effective method. Draglines have been used economically where a large number of dugouts, located in the same vicinity, are available for construction by the same machine. This method of construction would of course necessitate community organization.

Water from Dugouts for Household Use.

In case it is desired to utilize a dugout for domestic purposes some system of filtering and purifying the water should be installed.

A common and easily constructed type consists of digging a trench about 2 feet or 3 feet wide, out from the side of the dugout for a distance of 30 to 50 feet. At the end of the trench an ordinary well hole is dug and equipped with cribbing and a pump. (See Fig. 2.)

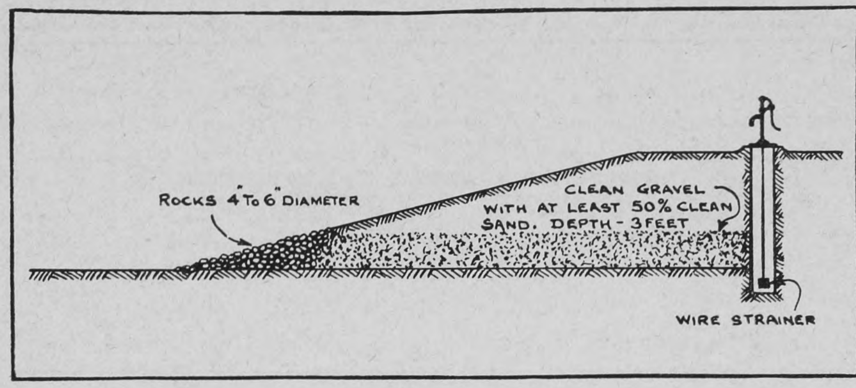


FIGURE. 2.

The trench is then filled to a depth of 2 or 3 feet with a clean gravel, containing at least 50 per cent. sand, as shown in Figure 2. The remainder of the trench may then be backfilled with ordinary earth. It should be noted that the end of the trench in the dugout contains stones from 2 inches to 6 inches in diameter. This is to prevent clogging of the sand filter with mud or debris.

Protection of the Dugout.

In order to have a clean water supply the dugout must be protected from pollution by animals. This can be done by building a fence around both the well and the dugout. Water is then pumped into a trough outside the fence for consumption by stock. The well should have a tight cover and be banked with good clay, so that surface water will run away from it rather than into it. (See Fig. 2.) Dugouts may be protected from excessive evaporation losses by planting hedges around them; these hedges catch snow, increasing the water supply, but should not be planted closer than 50 feet from the dugout.

Sending Water Samples for Laboratory Examination.

Anyone in the Province desiring an opinion on the sanitary quality of the water supply for human consumption may obtain such from the Division of Sanitation of the Department of Public Health on request. This service entails no cost except postage.

The applicant should first write to the above department in Regina describing the type of construction, and asking for a sterilized bottle, with instructions as to how to take the sample. This will be examined in the laboratory at Regina, following which a complete report will be mailed to the applicant regarding the quality of the water, and containing an opinion as to whether it is safe for human consumption.

Winter Use of Dugouts.

Unless a dugout is very deep, i.e., 10 feet or more, there is danger of freezing to the bottom in winter. If the water is low in the fall and

there is some danger of freezing to the bottom, this could possibly be prevented by cutting holes in the ice, when it freezes to a thickness of about 8 inches, and driving posts down into the mud bottom. These posts should be about 6 feet apart each way. (See Fig. 3.)

WEN FROM MANITOBA AGRICULTURAL BULLETIN, 1922, BY G.L. SHANKS. PROF. OF AGRIC. ENGINEERING

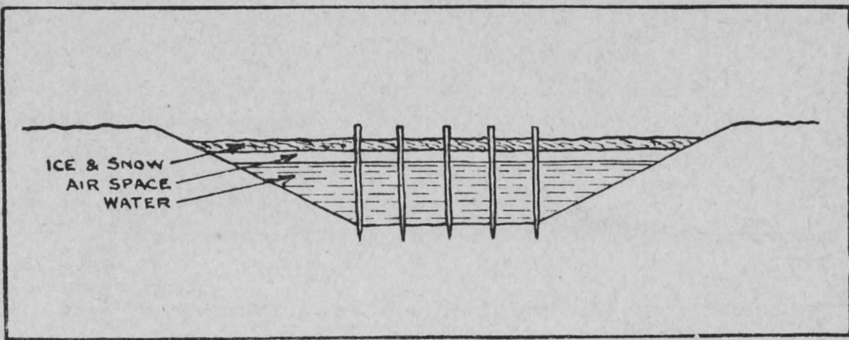


FIGURE. 3.

The water will freeze around the posts and as water is taken from the dugout the posts will support the ice sheet leaving an air space between the water surface and the ice. This air space acts as an insulator and reduces further freezing considerably.

Water Rights.

In no case should construction be proceeded with until authorization has been obtained from the Water Rights Branch (see Water Rights Act) and this particularly applies to cases where works are located on natural channels.

Special cases may arise where in the opinion of the engineer authority may be given, but it must be clearly understood that no financial assistance will be considered unless the works have been legally authorized, and works constructed without such authorization will be at owner's risk.

CONSTRUCTION OF DOMESTIC DAMS

Before making application for a survey or for financial assistance for the construction of dams, possibilities should be investigated with reference to:

(a) A suitable dam site.
(b) A suitable reservoir.
(c) The drainage area tributary to the site.
(d) The subsoil at the site.

Choosing the Site.

A dam will necessarily be placed in a draw or coulee. The narrowest point on the coulee should be chosen for the dam, provided other conditions are satisfactory; this will save work.

Reservoir.

Reservoirs should be ten feet deep, for an all year supply and of small area. Building a dam where a large acreage will be flooded to a

shallow depth of only 3 or 4 feet is not good practice, as it is very wasteful, due to excessive seepage and evaporation losses. Such a condition would encourage the growth of weeds and grass in the reservoir, which would tend to make the water disagreeable.

Drainage Area.

After a proposed site has been chosen, an estimate of the size of the drainage area must be made. In general, for the average stock watering dam, this area should not be less than 100 acres, except in certain cases where the coulee is precipitous and narrow. In these cases the reservoir would be very small and drainage area as low as 60 acres may be sufficient. Any drainage area greater than this adds to the cost of spillway.

Subsoil Conditions.

Test holes shall be sunk to a depth of 6 or 8 feet at the site to determine the type of subsoil. This should be clay or a clay mixture. Sand or gravel with less than 3 feet of clay covering would be a doubtful condition from the standpoint of reservoir leakage.

Making Application.

When the farmer has assured himself that he has a satisfactory site for a dam he should make application to the proper authorities for a survey. (See under Dugouts.) He should on no account proceed with construction until a survey has been made and the dam and spillway staked by a Government engineer, and authorization issued by the Water Rights Office.

Plans.

A plan is prepared of all projects constructed under the Prairie Farm Rehabilitation Programme. A tracing of the plan is eventually sent to the applicant, together with a print, with instructions to date and sign in ink the tracing and return it to the Water Rights Office, Regina. The print is to be retained by the applicant for his own use and guidance.

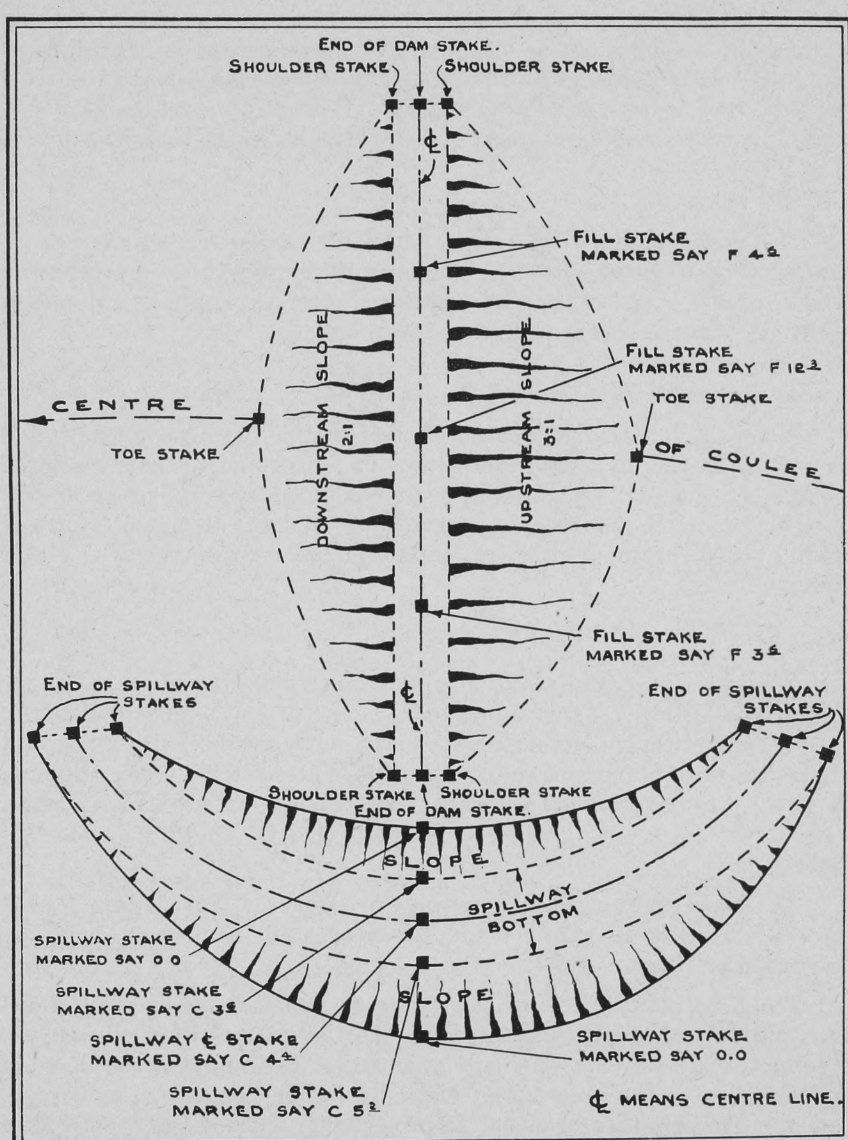
Right-of-Way.

All works authorized under the provisions of *The Water Rights Act* are subject to acquiring right-of-way over any lands not owned by the applicant.

The filed plan will show the extent to which lands or road allowances will be affected by the project. In the case of road allowances, whether travelled or not, the consent must be obtained, for the flooding by reservoirs or the crossing of same by ditches or any other works, from the Municipality or Local Improvement District and the Department of Highways and Transportation. When lands other than the applicant's are affected by the project, easement for right-of-way covering the area required must be obtained by the applicant. In order to assist the applicant in acquiring easement, forms are provided by the Department, but the arrangements for obtaining such easement are entirely a matter to be settled between the applicant and the owner of the lands affected.

Construction.

Dams and spillways shall be built strictly in accordance with the stakes set by the engineer. These stakes will be marked with the cut or fill at that point, in feet and tenths of feet; i.e., C1.6 means, cut 1 foot and 6 tenths of a foot, below the ground at that point where the stake is driven. Also, F2.8 means, fill 2 feet and 8 tenths of a foot at that point. (See Fig. 4.)



PLAN OF DAM AND SPILLWAY
LOOKING FROM ABOVE

FIGURE 4.

In addition to cut stakes placed on the centre line (CL), of the spillway, and the fill stakes placed on the dam (CL), there will also be

stakes to show the location of the toes of the dam, the ends of the culvert, if any, the ends of the spillway, and at the points where the spillway slopes cut the natural ground.

Methods of Construction.

Small dams may be built with any of the smaller dirt moving machines, the Fresno being the most common. The ground must be cleared of all brush and stones or other debris. Corrugations should then be made parallel to the centre line of the dam, by means of plowing deep furrows about 4 or 5 feet apart. These will act as keyways to key the dam to the ground.

Good clay, or clay mixtures, should now be excavated from some convenient point and deposited on the base of the dam. A mixture of equal parts of clay and sand or gravel is the best material for dam building, if this is available. The fill should be placed in layers of a foot or so in thickness, one complete layer being placed before another is started. This ensures that the fill will be compacted by horses and implements passing over it. If water is available the wetting of each layer will help greatly in compacting the fill.

In cases where a shallow porous strata overlays an impervious strata such as clay or hardpan, it may be necessary to excavate a narrow trench lengthwise to the dam and refill the trench with a good puddled clay mixture in order to prevent water escaping under the dam and destroying it.

The fill shall be carried up to the height shown on the stakes *plus 10 per cent.,* i.e., if the fill at a certain point is shown as 10 feet by the stake, this should be made 11 feet to allow for subsequent settlement of the fill. Experience shows that a fill 10 feet high, even if well compacted during construction, will finally settle about 1 foot after completion.

Slopes on the Dam.

Slopes most commonly used on the dam are 3 to 1 on the upstream side and 2 to 1 on the downstream side. A 3 to 1 slope means that for every foot of vertical rise, the distance horizontally will be three feet.

In construction, the fill should be started at the toe stakes and a slope built by estimating for the first 3 or 4 feet. Then the slope can be checked by taking a 2" x 4" scantling of known length, placing an ordinary carpenter's level on top and laying one end of the scantling on the slope, the other end pointing towards the toe of the dam. When the scantling is level measure down from the bottom of it to the slope surface or toe. (See Fig. 5.)

Example: Suppose it is desired to check a 3 to 1 slope. Assume that a 2" x 4" scantling 12 feet long is used; when one end is placed on the slope and levelled, the vertical distance to the slope or toe from the **other** end should be 4 feet, i.e., one-third of the length of the scantling. (1 in 3 slope.)

A similar method is used for a 2 to 1 slope, except that in this case the vertical distance should be *half* the horizontal distance; i.e., if a 12 foot rod is used, the vertical distance at the lower end should be 6 feet instead of 4 feet.

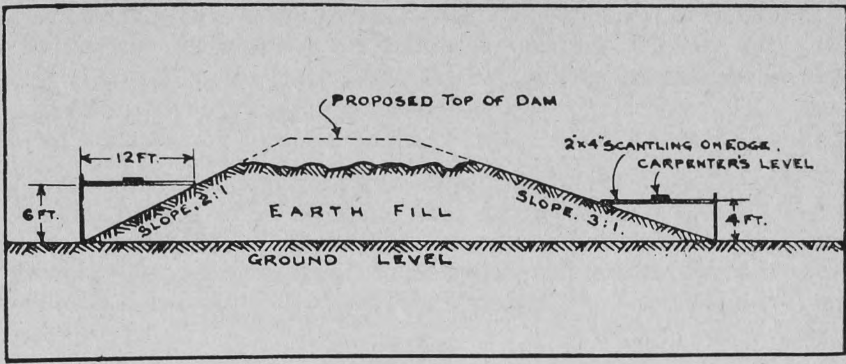


FIGURE. 5

Width of Top.

The width of the top for the average dam of, say, 12 feet in height may be from 6 to 12 feet, 8 feet being a common width. This will in any case be decided by the engineer, and staked by him, indicated by stakes marked "shoulder".

Spillway or Overflow.

A well constructed spillway is essential to the life and safety of any dam. The usual method on small or moderate size drainage areas is to cut a spillway around one end of the dam. If possible, it is best to have the spillway some distance away from the dam. In any case, it should be cut in solid ground. A spillway cut through the centre of the dam, in the loose fill for instance, would wash out immediately. *Special care must be given to clearing spillway from ice and snow before spring run-off.*

However, a proper spillway will be staked by the engineer and the builder must be very careful to follow the stakes. Special care should be taken to make the bottom of the spillway flat and smooth and *level.* The reason for this is that the overflow water will then spread out in a thin sheet, and will not have a tendency to wash and cut, as it would if the water ran in a small deep channel through the spillway, and probably along one side only.

Protection of Water Slope and Spillway.

The water slope of the dam must be protected from wash by wave action. If stones are available a layer from 9 inches to 12 inches thick placed on edge on the entire slope generally affords adequate protection, especially if the slope is first covered with 2 or 3 inches of gravel. A layer of brush or straw, preferably flax straw, tied down with wire attached to stakes driven into the embankment, has proved satisfactory.

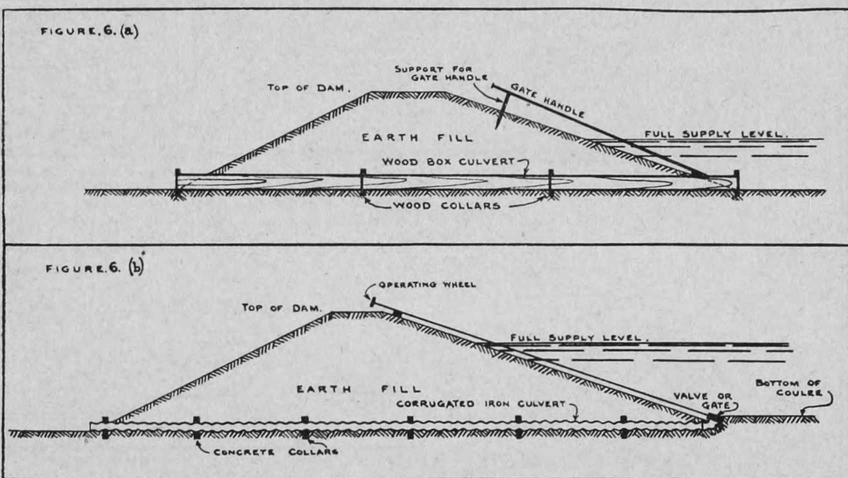
Spillways, especially the lower or downstream end, should also be rip-rapped with stones. If washing occurs in a spillway, it invariably begins at the outlet end; hence the special precautions at this danger point, and back into the spillway cut for some distance. The entire bottom and side slopes should be covered for the same distance.

Culverts or Outlet Pipes.

When culverts are necessary they will be specified as to size and type by the engineer, or by plans submitted by the Water Rights Branch. These shall be installed according to stakes set by the engineer. Collars around the pipe or culvert must be provided at specified intervals of not more than 10 feet as water will creep along the outside of the pipe if these are not provided, and a washout will eventually occur. Gates shall be constructed as specified. (See Fig. 6a.)

Square wooden culverts and wooden gates are the cheapest, and most conveniently procured; these may be used where the culvert is not more than four feet below the full water level of the reservoir. Wooden culverts, however, are subject to deterioration and may have to be replaced after a few years, unless creosoted.

Where the culvert is placed at a depth greater than 4 feet below the water level, an approved type of iron gate and corrugated iron pipe should be used. In this latter case it will be necessary to use concrete collars around the pipe. (See Fig. 6b.)

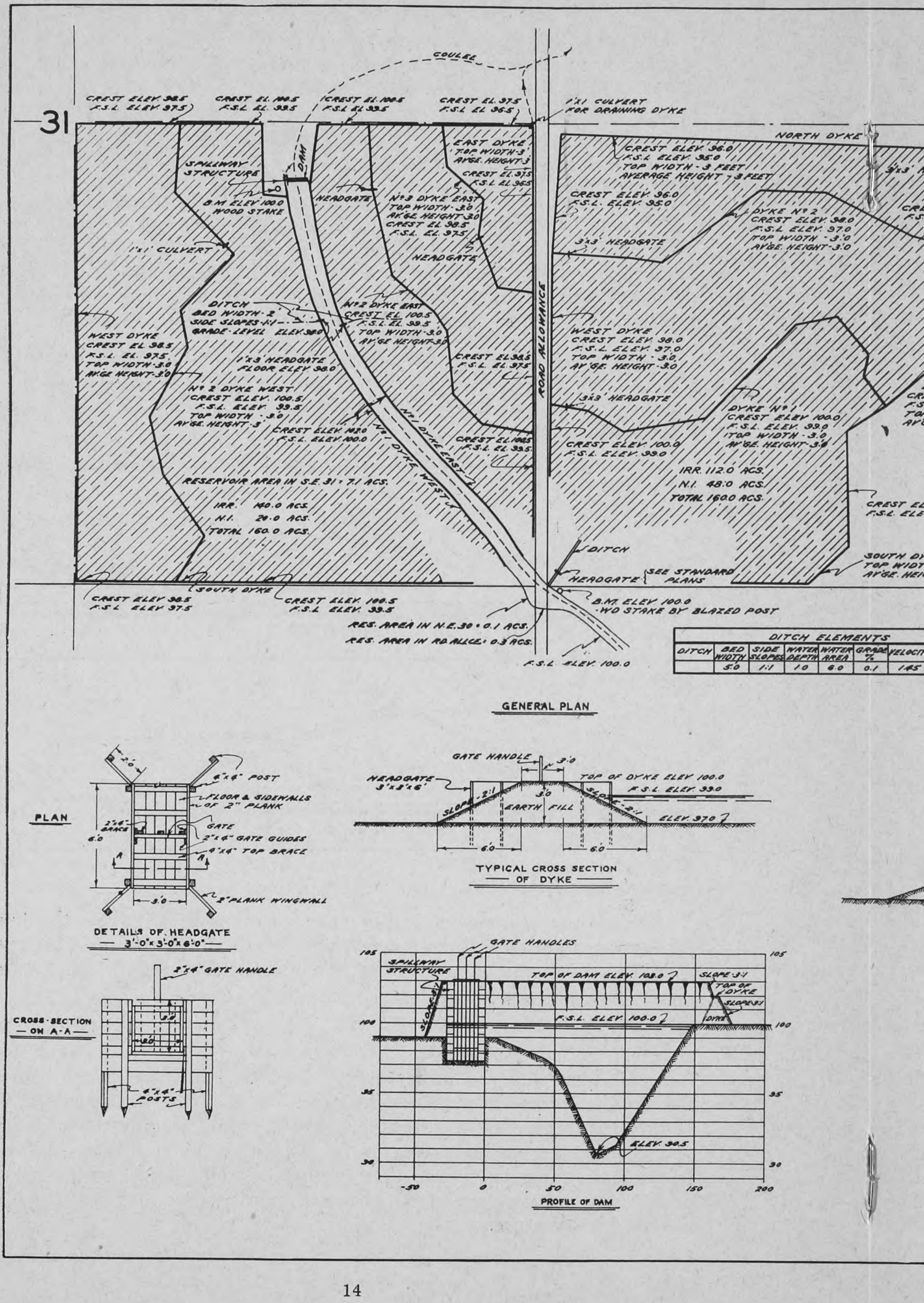


Dugout Above the Dam.

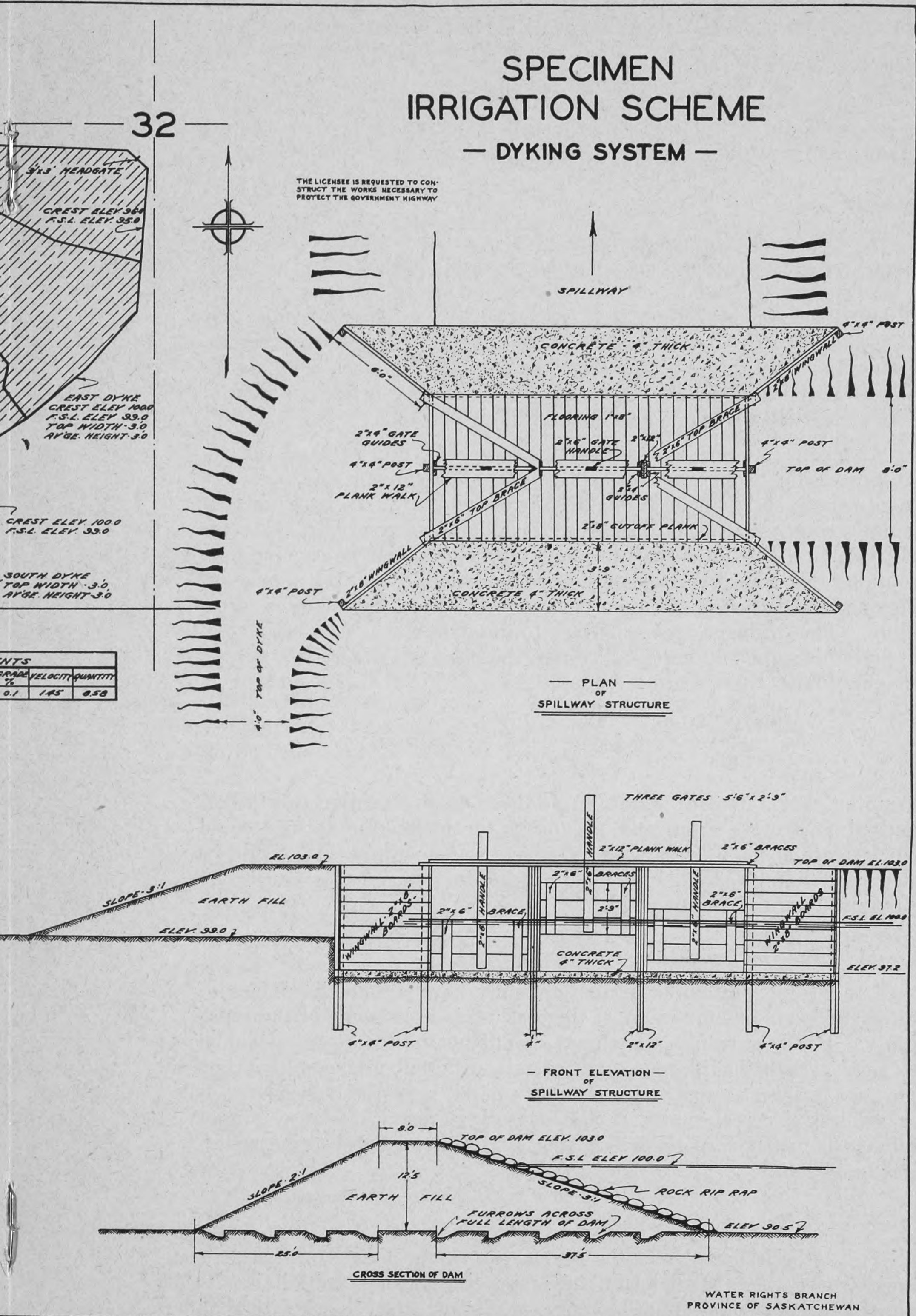
Sometimes it is economical to make a shallow dugout above the dam to increase the depth of water. Where this is done, the solid ground should not be disturbed near the toe of the dam. At least 10 feet of solid ground must be left along the toe.

Water Right.

All dams must be authorized by the Water Rights Branch before the builder proceeds with construction. When this authorization is obtained it means that a certain quantity of water, usually the capacity of the reservoir, has been reserved for the use of the applicant. If this is not done, other parties on the same water course could later reserve all the water available, and the owner of the first dam may be forced to remove his structure.



31
COULEE
CREST ELEV. 98.5 F.S.L. ELEV. 97.5
CREST EL. 100.5 F.S.L. EL. 99.5
CREST EL. 97.5 F.S.L. EL. 96.5
1'x1' CULVERT FOR DRAINING DYKE
NORTH DYKE
EAST DYKE TOP WIDTH-3' AV'GE. HEIGHT-3
SPILLWAY STRUCTURE
DAM
B.M. ELEV. 100.0 WOOD STAKE
HEADGATE
Nº 3 DYKE EAST TOP WIDTH-3.0 AV'GE. HEIGHT-3.0 CREST EL. 98.5 F.S.L. EL. 97.5
CREST ELEV. 36.0 F.S.L. ELEV. 35.0 TOP WIDTH - 3 FEET AVERAGE HEIGHT - 3 FEET
CREST ELEV. 36.0 F.S.L. ELEV. 35.0
DYKE Nº 2 CREST ELEV. 98.0 F.S.L. ELEV. 97.0 TOP WIDTH - 3.0 AV'GE. HEIGHT-3.0
3'x3' HEADGATE
1'x1' CULVERT
DITCH BED WIDTH-2' SIDE SLOPES-1:1 GRADE-LEVEL ELEV. 98.0
Nº 2 DYKE EAST CREST EL. 100.5 F.S.L. EL. 99.5 TOP WIDTH-3.0 AV'GE HEIGHT-3.0
ROAD ALLOWANCE
WEST DYKE CREST EL. 98.5 F.S.L. EL. 97.5 TOP WIDTH-3.0 AV'GE HEIGHT-3.0
1'x3' HEADGATE FLOOR ELEV. 98.0
CREST EL. 98.5 F.S.L. EL. 97.5
WEST DYKE CREST ELEV. 98.0 F.S.L. ELEV. 97.0 TOP WIDTH - 3.0 AV'GE. HEIGHT - 3.0
3'x3' HEADGATE
Nº 2 DYKE WEST CREST ELEV. 100.5 F.S.L. ELEV. 99.5 TOP WIDTH - 3.0 AV'GE. HEIGHT-3'
CREST ELEV. 101.0 F.S.L. ELEV. 100.0
Nº 1 DYKE EAST
Nº 1 DYKE WEST
CREST EL. 100.5 F.S.L. EL. 99.5
DYKE Nº 1 CREST ELEV. 100.0 F.S.L. ELEV. 99.0 TOP WIDTH - 3.0 AV'GE. HEIGHT - 3.0
CREST ELEV. 100.0 F.S.L. ELEV. 99.0
IRR. 112.0 ACS. N.I. 48.0 ACS. TOTAL 160.0 ACS.
RESERVOIR AREA IN S.E. 31 - 7.1 ACS.
IRR. 140.0 ACS. N.I. 20.0 ACS. TOTAL 160.0 ACS.
DITCH
HEADGATE SEE STANDARD PLANS
SOUTH DYKE
CREST ELEV. 98.5 F.S.L. ELEV. 97.5
CREST ELEV. 100.5 F.S.L. ELEV. 99.5
B.M. ELEV. 100.0 WD STAKE BY BLAZED POST
RES. AREA IN N.E. 30 = 0.1 ACS.
RES. AREA IN RD. ALLCE. = 0.3 ACS.
F.S.L. ELEV. 100.0
DITCH ELEMENTS
DITCH | BED WIDTH | SIDE SLOPES | WATER DEPTH | WATER AREA | GRADE % | VELOCITY
5.0 | 1:1 | 1.0 | 6.0 | 0.1 | 1.45
GENERAL PLAN
PLAN
2.0
6"x4" POST
FLOOR & SIDEWALLS OF 2" PLANK
2"x6" BRACE
6.0
GATE
2"x4" GATE GUIDES
4"x4" TOP BRACE
A
3.0
2" PLANK WINGWALL
DETAILS OF HEADGATE 3'-0"x3'-0"x6'-0"
2"x4" GATE HANDLE
CROSS-SECTION ON A-A
3.0
2.0
4"x4" POSTS
GATE HANDLE
3.0
HEADGATE 3'x3'x6'
TOP OF DYKE ELEV. 100.0
F.S.L. ELEV. 99.0
SLOPE 2:1
EARTH FILL
ELEV. 97.0
6.0
TYPICAL CROSS SECTION OF DYKE
GATE HANDLES
SPILLWAY STRUCTURE
TOP OF DAM ELEV. 103.0
SLOPE 3:1
TOP OF DYKE
F.S.L. ELEV. 100.0
DYKE
ELEV. 90.5
105
100
95
90
-50
0
50
100
150
200
PROFILE OF DAM


SPECIMEN
IRRIGATION SCHEME
— DYKING SYSTEM —
32
THE LICENSEE IS REQUESTED TO CONSTRUCT THE WORKS NECESSARY TO PROTECT THE GOVERNMENT HIGHWAY
SPILLWAY
CONCRETE 4" THICK
4"x4" POST
2"x8" WINGWALL
FLOORING 1"x8"
2"x4" GATE GUIDES
2"x6" GATE HANDLE
2"x12"
2"x6" TOP BRACE
4"x4" POST
TOP OF DAM 8'-0"
2"x12" PLANK WALK
2"x4" GUIDES
2"x8" CUTOFF PLANK
3'-9"
CONCRETE 4" THICK
4'-0" TOP OF DYKE
EAST DYKE
CREST ELEV 100.0
F.S.L. ELEV 99.0
TOP WIDTH 3.0
AV'GE. HEIGHT 3.0
CREST ELEV. 100.0
F.S.L. ELEV. 99.0
SOUTH DYKE
TOP WIDTH 3.0
AV'GE. HEIGHT 3.0
PLAN OF SPILLWAY STRUCTURE
THREE GATES 5'-6" x 2'-3"
HANDLE
2"x12" PLANK WALK
2"x6" BRACES
TOP OF DAM EL.103.0
EL.103.0
SLOPE 3:1
EARTH FILL
ELEV. 99.0
WINGWALL 2"x8" BOARDS
2"x6" BRACE
2"x6" BRACES
2'-9"
F.S.L. EL 100.0
CONCRETE 4" THICK
ELEV. 97.2
4"x4" POST
4"
2"x12"
4"x4" POST
— FRONT ELEVATION — OF SPILLWAY STRUCTURE
8.0
TOP OF DAM ELEV. 103.0
F.S.L. ELEV 100.0
12.5
SLOPE 2:1
EARTH FILL
SLOPE 3:1
ROCK RIP RAP
FURROWS ACROSS FULL LENGTH OF DAM
ELEV 90.5
25.0
37.5
CROSS SECTION OF DAM
WATER RIGHTS BRANCH
PROVINCE OF SASKATCHEWAN

CONSTRUCTION AND OPERATION OF IRRIGATION PROJECTS

Construction of the Dam.

If the construction of an irrigation dam is contemplated, the same procedure should be followed as for a stock watering dam. Construction methods, as far as the dam itself is concerned, are very similar.

Drainage Area.

A considerably larger drainage area is usually required, however, the size, of course, depending upon the reservoir capacity and the area of land to be irrigated. Measurements taken in various parts of Southern Saskatchewan show that from 15 to 35 acre-feet of water can be expected to run off from each square mile, as a long term average. This applies only to the plains area, the run-off from such areas as the Cypress Hills being much higher. (One acre-foot is the amount of water which will cover one acre to a depth of one foot.)

Assuming 20 acre-feet per square mile as a fair average run-off, then a reservoir of 20 acre-feet capacity should require a drainage area of one square mile, in order to fill up every year. To take another example: Suppose a farmer has a site for a dam and reservoir, also some irrigable land, and he desires to know how much land he can irrigate. Assuming that a reservoir of ample size is available, and the acreage of irrigable land is boundless, then obviously the limiting factor is water supply. The drainage area tributary to the dam site is now estimated. Suppose this to be 300 acres. Then on the basis of 20 acre-feet run-off per square mile, there will be available:

$$\frac{300 \times 20}{640} = 9.4 \text{ acre-feet.} \quad \text{(Approx.)}$$

Assuming that 1 foot of water, in addition to the regular rainfall, is required to grow a crop, and providing for losses, the farmer could then irrigate about 6 acres with the above water supply. It should be noted here that $1\frac{1}{2}$ feet is the legal duty of water, and this much may be required for maximum yield.

Suitable Land for Irrigation.

Land to be put under irrigation must have a smooth surface of uniform slope in one direction, if the best use is to be made of the water supply. For best results the slopes should not be too steep, although this may vary with different types of soil, different methods of irrigation, and different crops. On the other hand, a perfectly level flat is not so desirable, especially if the subsoil is heavy, because proper drainage is nearly impossible, and the land will tend to become waterlogged and sour.

Nature of Soil.

Soil to be irrigated must be reasonably free of alkali. Light soils require more water than heavy soils, especially if the subsoil is also light. Light loam soils cannot be irrigated on very steep slopes with good

results, because they will wash easily. On the other hand, light subsoils are preferable if the land is very flat and level, because under-drainage is effected and, consequently, the soil will not become water-logged.

Heavy soils can be irrigated on steeper slopes, as they will not wash so easily, and will retain the water. Some slope is essential on heavy lands in order to get proper drainage, for the reasons mentioned above. On the other hand, certain heavy soils may not absorb water readily.

It must be remembered that irrigation and drainage go hand in hand. Irrigation water of good quality, when applied to the land, will tend to wash away undesirable matter such as alkali from the soil if good drainage is provided.

Storage and Headworks.

The average individual irrigation scheme in Southern Saskatchewan will consist of a dam across a coulee or creek, creating a reservoir in which will be caught and stored the run-off from melting snow in spring, and summer rains. Through this dam a culvert or outlet pipe is placed, equipped with a valve or gate. This pipe will rest on solid ground on one of the slopes of the coulee, and at such a height that water can most conveniently be transported by a ditch to the land to be irrigated.

Distribution System.

The distribution system consists of a main ditch or canal leading from the outlet pipe to the irrigable land, and as many lateral or branch ditches as may be required. These ditches may or may not be equipped with certain structures such as drops, weirs and check gates, etc., depending upon the slope of the land.

Ditch Sizes and Grades.

The per cent. grade of a ditch is the amount of fall it has in feet per hundred. That is, a ditch 100 feet long, with one end 1 foot lower than the other end, would have a grade of 1 per cent. Naturally, the steeper the grade the faster the water will run, for any given ditch. On the other hand, the smaller and shallower the ditch, the more slowly the water will run, for a given grade.

Construction of Ditches.

Small ditches can be made with an ordinary plow. One furrow is made about 8 inches deep, following the engineer's ditch stakes. On the return trip, another furrow is thrown the other way, making a ditch double the plow width, with a bank on either side. The ditch can then be cleaned up to the proper cross-section by any suitable method, either by hand or by constructing a ditcher out of planks and drawing it with horses.

Velocity of Water in Ditches.

If the water runs too fast in the ditch it will wash and undermine the sides, causing them to cave in. The allowable velocity, however,

varies widely with the type of soil. Velocities as low as 1 foot per second may be required to prevent washing on soft loam soils, while for certain heavy soils over 3 feet per second may be allowed. For the average clay loams of Southern Saskatchewan 1½ feet per second is probably a fair average velocity.

Most small irrigation schemes will probably have a main ditch of 2 feet bottom width with 2 to 1 side slopes, carrying about 8 inches of water. (See Fig. 7) In order to have a velocity of 1½ feet per second, such a ditch should have a fall of about 2½ tenths of a foot, or 3 inches in 100 feet. In general, a grade or fall of from 1 tenth to 3 tenths of a foot per 100 feet will be used, depending upon the type of soil, the lay of the land and the size of the ditch.

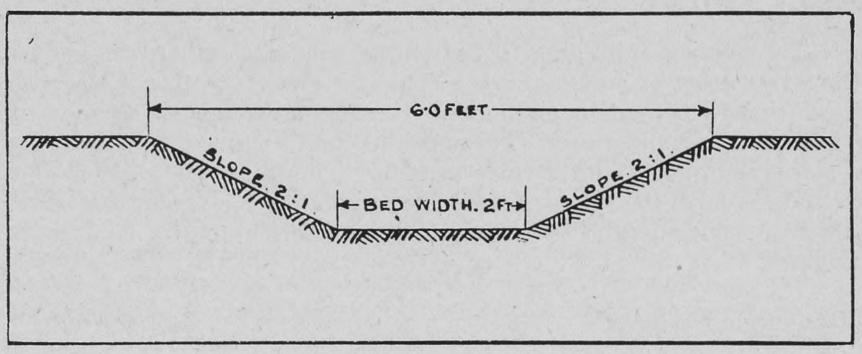


FIGURE. 7.

Drop Structures.

As is often the case, a dam may be located at a point which is considerably higher than the land to be irrigated. If ditches are run directly to the irrigated land they may have too much fall and washing may occur due to the water running too fast. In this case, it is necessary to run the ditch for a short distance at the allowable grade, say a fall of 3 tenths of a foot per hundred feet. Then a structure called a drop will be installed. (See Fig. 8.)

A drop consists essentially of a wooden box, set down in the ground. The ditch empties into this box, and a second ditch, at a lower level than the first, runs out of it. In other words, a small water fall is created in a place where precautions can be taken against washing. By installing several of these drop structures a ditch can be constructed on a fairly steep slope. Drops may sometimes be constructed of field stones where these are plentiful.

Method of Irrigating.

Several methods of irrigation are used, depending upon the slope of the land, the type of soil, the rate at which water is available, etc. Therefore, every irrigation scheme is a special problem and will have to be solved by the individual owner. However, certain methods may be prescribed, one of which, or possibly a combination of two or more, may be adopted as most suitable.

Free Flooding from Contour Ditches. (See Fig. 9.)

The head or main ditch is run down the slope along one side of the land to be irrigated. "Contour ditches" are then taken off more or less at right angles to the head ditch and run along the slope, with just enough fall to permit a flow of water. (A contour is a line, every point on which is the same height above sea level.)

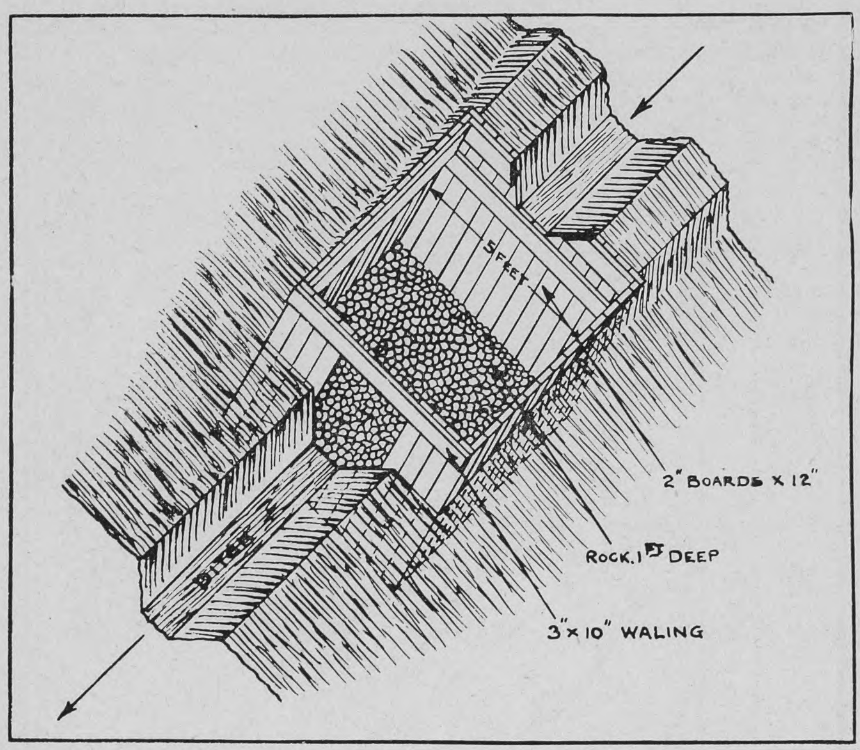


FIGURE. 8.

These contour or lateral ditches should be from 50 feet to 300 feet apart, depending upon the soil and the steepness of the slopes. On steep slopes the ditches should be close together, while on flatter slopes they may be farther apart. Slopes may vary from a fall of 2 feet per hundred feet for heavy soils to 1 inch per hundred feet for soft loam soils.

Method of Procedure for Free Flooding.

At a point probably 200 or 300 feet from the head ditch a canvas dam is inserted in the lateral ditch, and the water turned into it. This raises the water in the ditch and allows it to flow over the side of the ditch and onto the land. When the portion of land above the canvas dam has been sufficiently flooded the dam is removed and placed farther down the ditch and the operation repeated. This system can be used on fairly steep slopes, and requires less grading or levelling than any other method.

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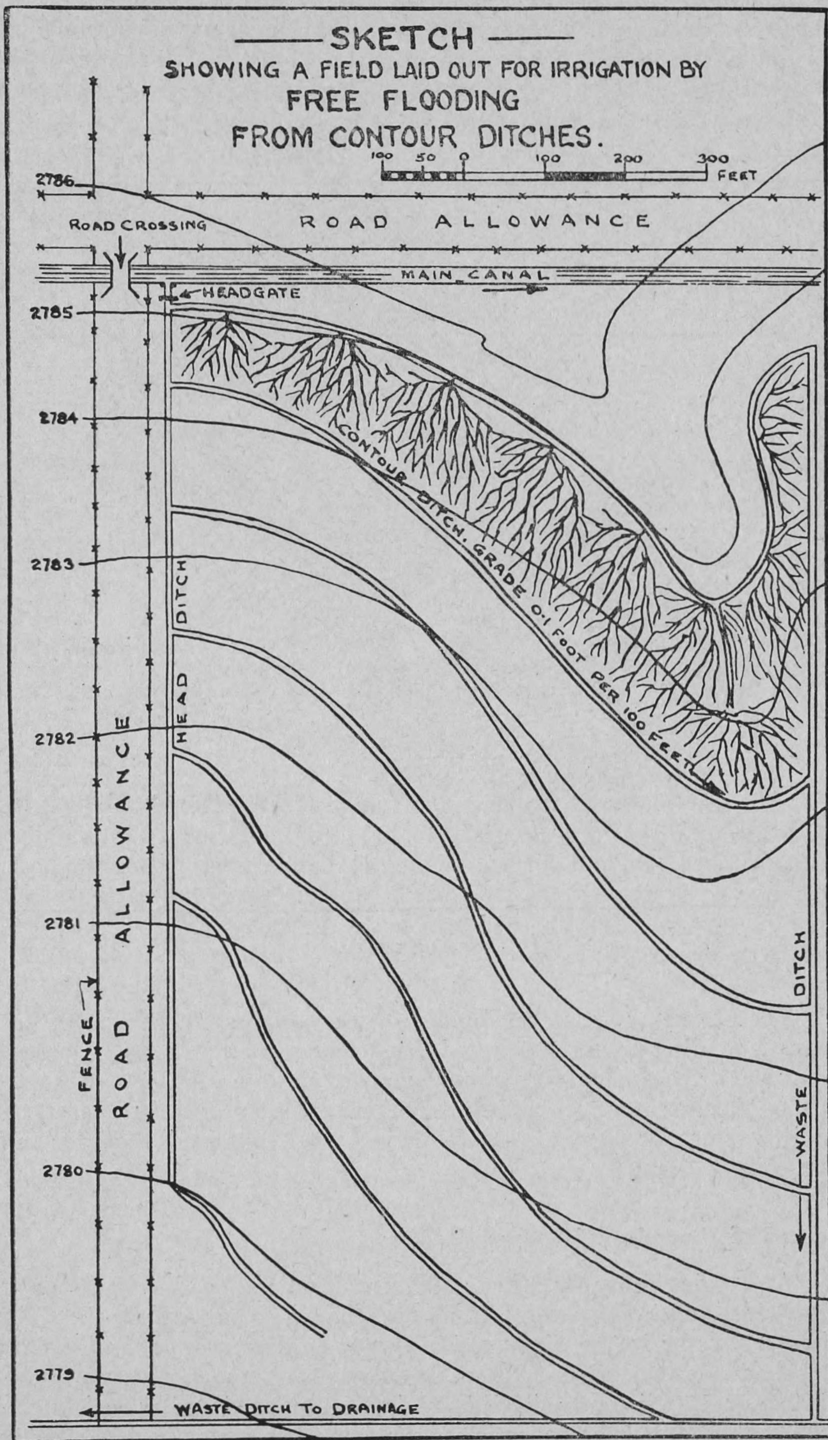

FIGURE. 9.

Use of the Canvas Dam. (See Fig. 10.)

A piece of 12-ounce canvas about 4 feet by 6 feet is used with a 2 inch by 2 inch scantling fastened to one 6-foot side. The scantling is laid across the ditch and the canvas spread on the ditch bottom, held down with some earth. This acts as a temporary dam to raise the water in the ditch.

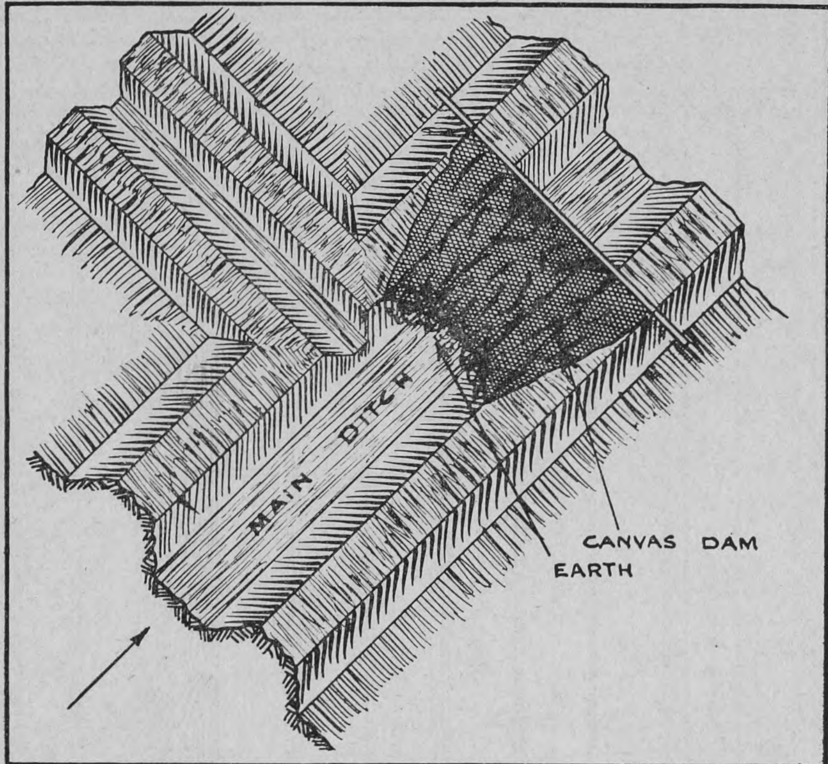

FIGURE. 10.

Border Ditch System. (See Fig. 11.)

The head or main ditch is run along the high side of the land and lateral ditches are taken off at right angles, running straight down the slope, parallel to each other and probably 50 feet apart. If the slope is too steep, the laterals may be taken down on a bias to the slope.

Method of Procedure for Border Ditch System.

As in the first system a canvas dam is placed some distance down from the head ditch and water allowed to back up and flow over the sides of the ditches, spreading over the land between. When the land is wet for an equal distance below the canvas dam, the dam is removed and replaced opposite the end of the wetted portion, where the operation is repeated.

An advantage of this system is that the land is divided up into rectangular portions and is therefore more easily farmed. This method also permits an even distribution of water, as only 100 feet or so is done at one time, and can be done quickly.

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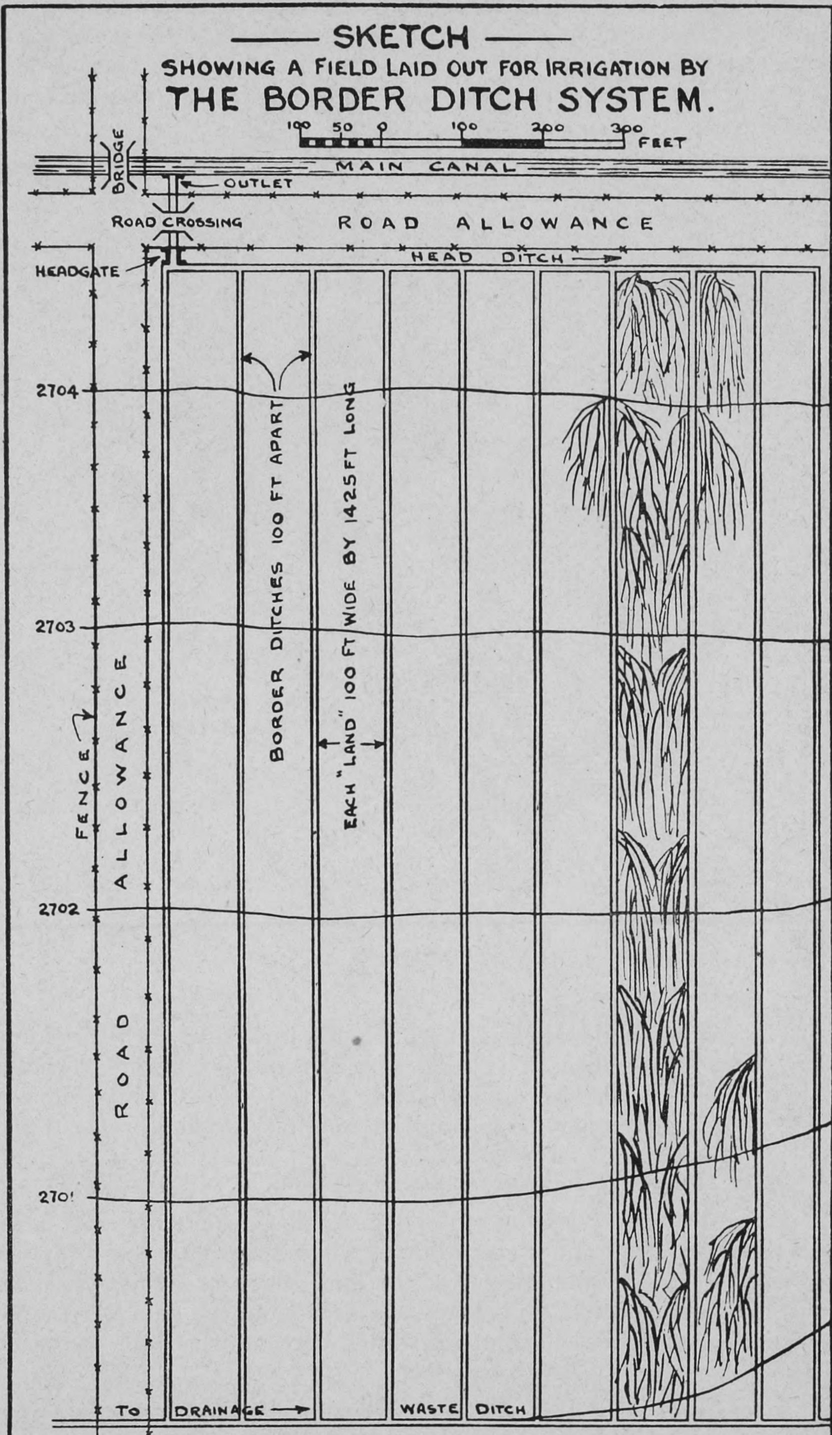

FIGURE. 11.

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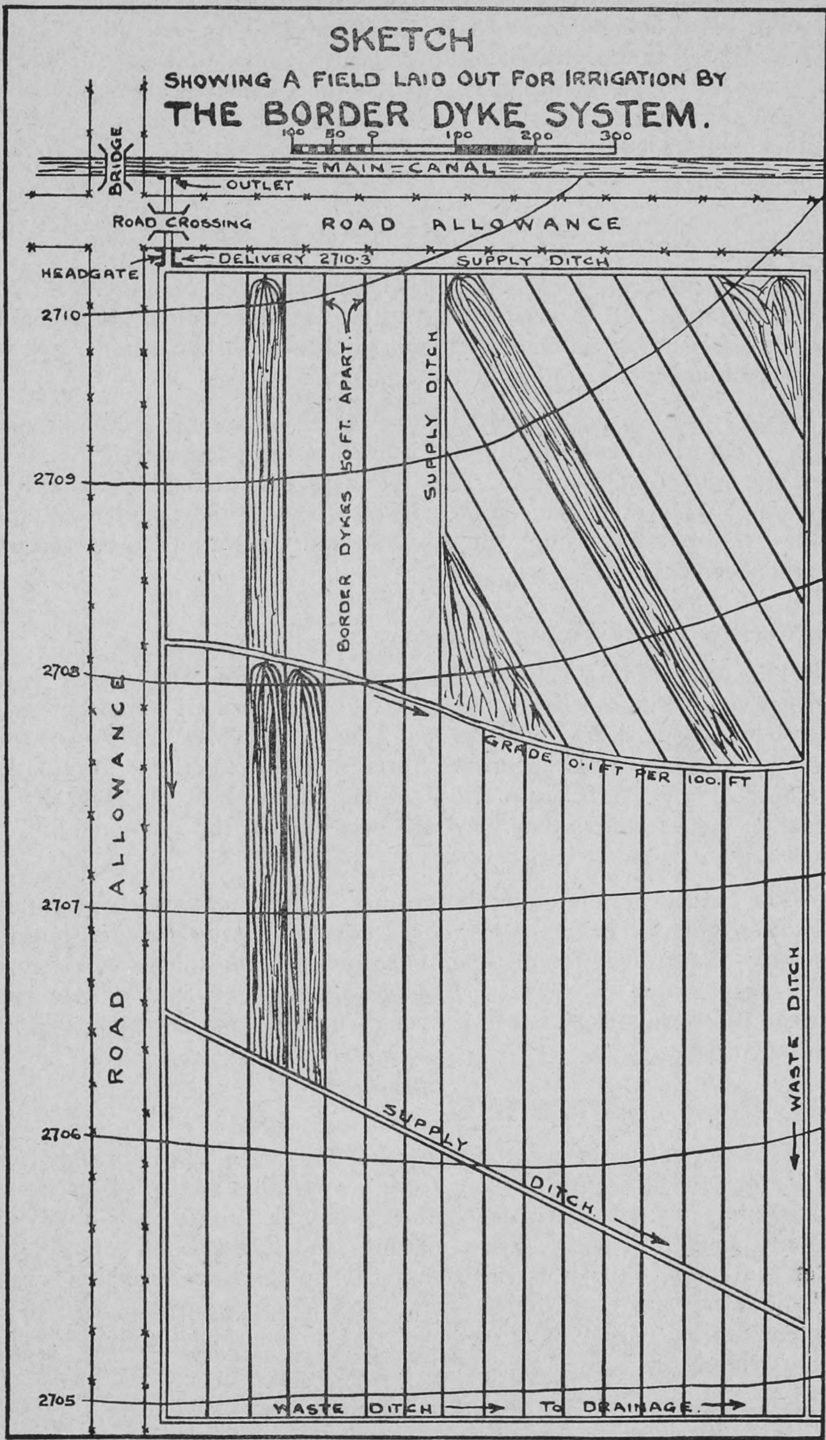


FIGURE. 12

The Border Dyke System. (See Fig. 12.)

This is the most expensive system and consists of low dykes, about 6 inches high, being run down the slope parallel to each other, about 50 feet apart. Supply ditches run along the slope, similar to the Free Flooding Method, except that they will be spaced farther apart, probably as much as 500 or 600 feet. Water can be run on the land very quickly by this method, and is suitable for permanent pasturage and fodder crops.

The Dyking or Pond System. (See Fig. 13.)

This is used on very flat land which has a fall of not more than 10 feet to the mile. It consists of constructing dykes along the slope at intervals depending on the steepness, so that the high water mark of one pond reaches the bottom of the next higher dyke.

The system is used where storage facilities are not available and water is diverted in the spring and stored in the ponds for a few days until the land is well soaked. It is found successful for irrigating hay meadows. Water is taken from a head ditch in the usual way, and drains are provided through the dykes so that the water can be drained off whenever desired.

The Corrugation or Furrow System.

This consists of a head ditch along the high side of the field, with furrows about 3 feet apart running straight down or, if too steep, on a bias to the slope. Water is turned into the furrows from the head ditch by means of miniature culverts made by nailing four laths together. These small pipes are placed in the bank of the head ditch, all at the same level, so that they will each deliver the same amount of water to their respective furrows.

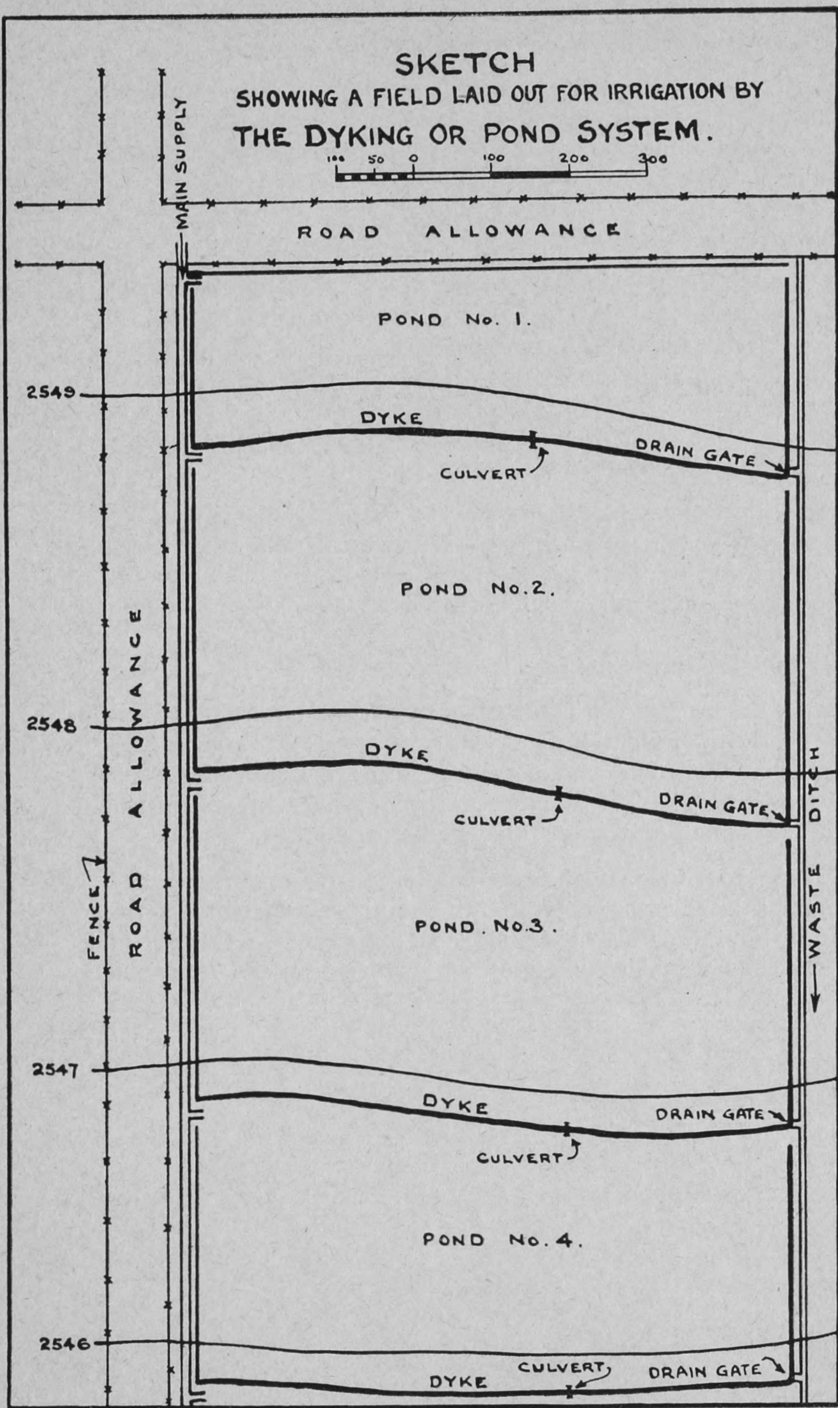
The furrow system of irrigation may be used on very steep slopes, falls of as much as 10 feet per hundred having been used where the soil is heavy. Naturally, this method of irrigation is most adapted to crops which are planted in rows, such as potatoes. The furrows are run between the rows and moisture is brought to the roots in some cases by capillary action.

Contour Terracing.

This can hardly be called a method of irrigation, but is primarily a method of preventing soil erosion from heavy rains, etc. It consists of constructing low dykes with a shallow ditch just above each dyke, on contours along hillsides. These furrows and dykes catch and retain water that would otherwise run straight down the slope, washing away the soil in its course. This retained water sub-irrigates the land in a manner similar to the dyke or pond system mentioned previously in this article.

Levelling the Land.

For the most economical use of water and the best results in the way of yield, the land should be levelled. That is, high spots should be



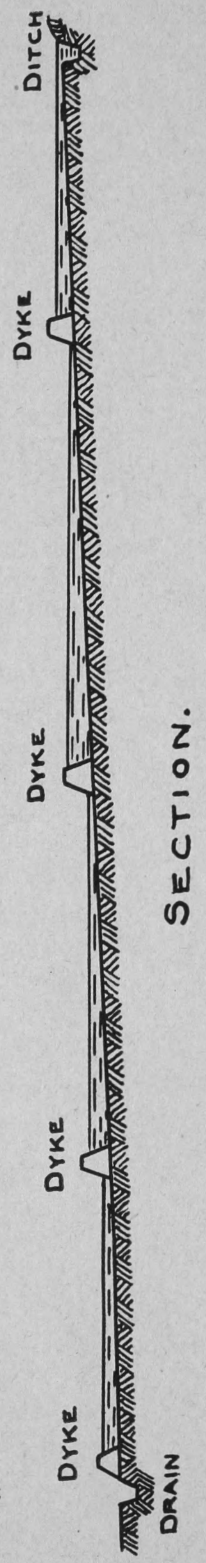


FIGURE. 13.

NOTE.—Variations of the above method can be devised in the field to suit particular conditions.

cut off and dumped into the low spots so that the surface will be smooth. This permits an even distribution of irrigation water.

The levelling can be done with an ordinary Fresno scraper, followed by wooden floats for the final smoothing operation. Plans of levelling and ditching equipment may be obtained by writing to the Water Rights Office, Regina.

Rate of Application of Water.

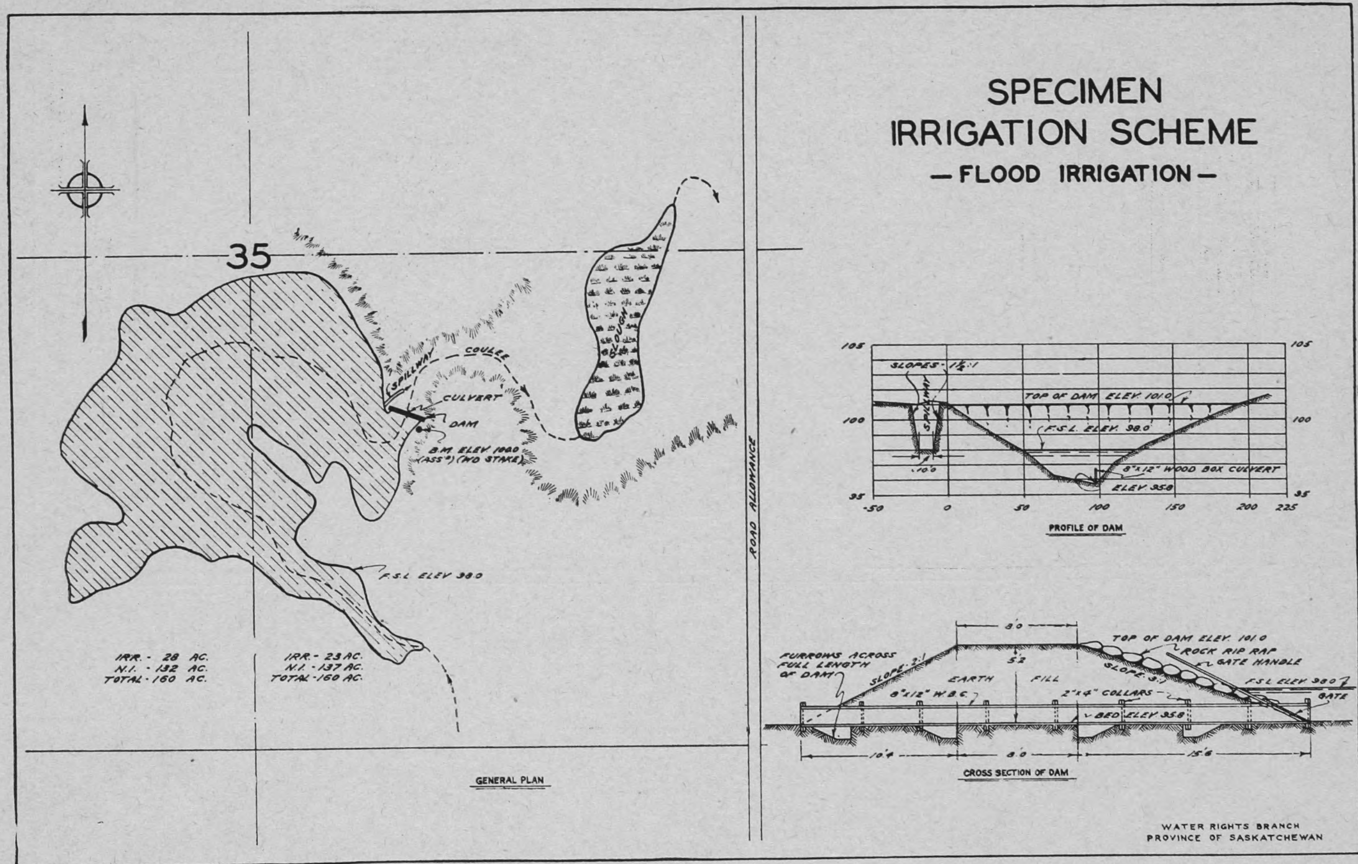
It it is possible, water should be applied quickly because in this way water can be spread over all the land before it has time to soak in near the ditch. If water is applied very slowly it will be found that it will soak into the land near the ditch while no water at all will reach the more remote areas. This is especially true where subsoils are sandy or gravelly. To irrigate quickly ditches should be large enough to carry a good irrigating head of water.

However, on very steep slopes it may be found that applying the water too rapidly may tend to wash the soil away. In this case it will be necessary to adjust the flow to the proper amount by means of the gate on the reservoir outlet pipe, or by other means.

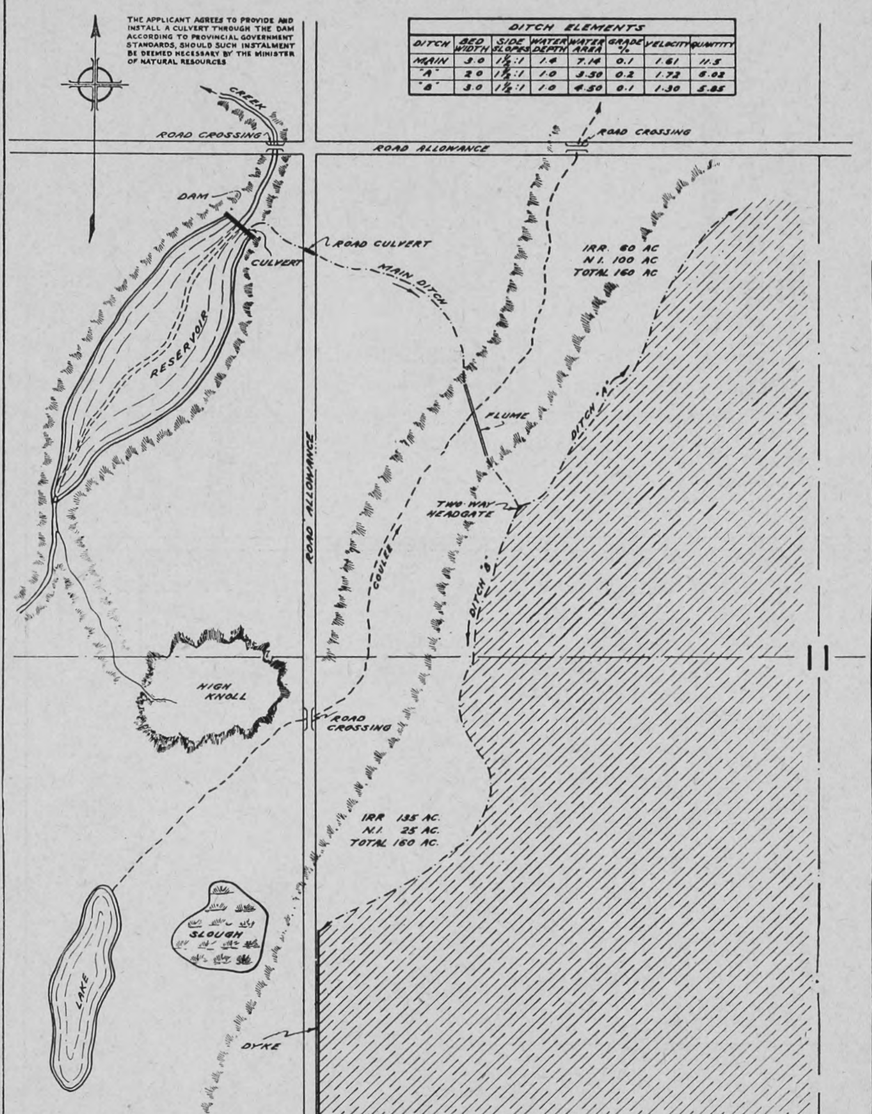
Time and Amount of Irrigation.

Experiments have shown that frequent light irrigations are preferable to few heavy irrigations. About four inches of water at each time, put on from two to four times during the growing season, has been found satisfactory. The number of irrigations will, of course, depend upon the amount of rainfall, the type of soil, etc.

Probably one four-inch irrigation around June 1st, another around June 20th, and a third around July 15th would be sufficient for the average year in Southern Saskatchewan. An irrigation in the fall of the year is good, as it ensures germination of the crop the following spring.


SPECIMEN
IRRIGATION SCHEME
— FLOOD IRRIGATION —
35
SPILLWAY
COULEE
CULVERT
DAM
B.M. ELEV 100.0 (ASS'D) (NO STAKE)
F.S.L. ELEV 98.0
IRR. - 28 AC.
N.I. - 132 AC.
TOTAL - 160 AC.
IRR. - 23 AC.
N.I. - 137 AC.
TOTAL - 160 AC.
GENERAL PLAN
ROAD ALLOWANCE
SLOPES - 1½:1
TOP OF DAM ELEV. 101.0
F.S.L. ELEV. 98.0
8"x12" WOOD BOX CULVERT
ELEV. 95.8
PROFILE OF DAM
FURROWS ACROSS FULL LENGTH OF DAM
SLOPE 2:1
EARTH FILL
8"x12" W.B.C.
2"x4" COLLARS
BED ELEV. 95.8
TOP OF DAM ELEV. 101.0
ROCK RIP RAP
GATE HANDLE
SLOPE 3:1
F.S.L. ELEV. 98.0
GATE
CROSS SECTION OF DAM
WATER RIGHTS BRANCH
PROVINCE OF SASKATCHEWAN

SPECIMEN IRRIGATION SCHEME



DITCH ELEMENTS							
DITCH	BED WIDTH	SIDE SLOPES	WATER DEPTH	WATER AREA	GRADE %	VELOCITY	QUANTITY
MAIN	3.0	$1\frac{1}{2}:1$	1.4	7.14	0.1	1.61	11.5
"A"	2.0	$1\frac{1}{2}:1$	1.0	3.50	0.2	1.72	6.02
"B"	3.0	$1\frac{1}{2}:1$	1.0	4.50	0.1	1.30	5.85

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